7 - System Module and User Interface

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List of Abbreviations

ASIC	Application Specific Integrated Circuit
BB	Baseband
BLUETOOTH, BT	Bluetooth
BSI	Battery Size Indicator
CBus	Control Bus connecting UPP_WD2 with UEM
CCP	Compact Camera Port
CPU	Central Processing Unit
DBUS	Data Bus
DSP	Digital Signal Processor
EGSM	Extended – GSM
GPRS	General Packet Radio Service
GSM	Group Special Mobile/Global system mobile
HF	Hands free
HFCM	Handsfree Common
HS	Handset
I/O	Input/Output
IHF	Integrated hands free
IR	Infra red
IrDA	Infrared Association
LCD	Liquid Crystal Display
MCU	Micro Controller Unit
MIC, mic	Microphone
PDA	Pocket Data Application

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PWB	Printed Wiring Board
RF	Radio Frequency
RFBUS	Control Bus For RF
SDRAM	Synchronous Dynamic Random Access Memory
SIM	Subscriber Identity Module
UI	User Interface
UEMK	Universal Energy Management (shrink version)
VCXO	Voltage Controlled Crystal Oscillator
VGA	Video Graphics Array

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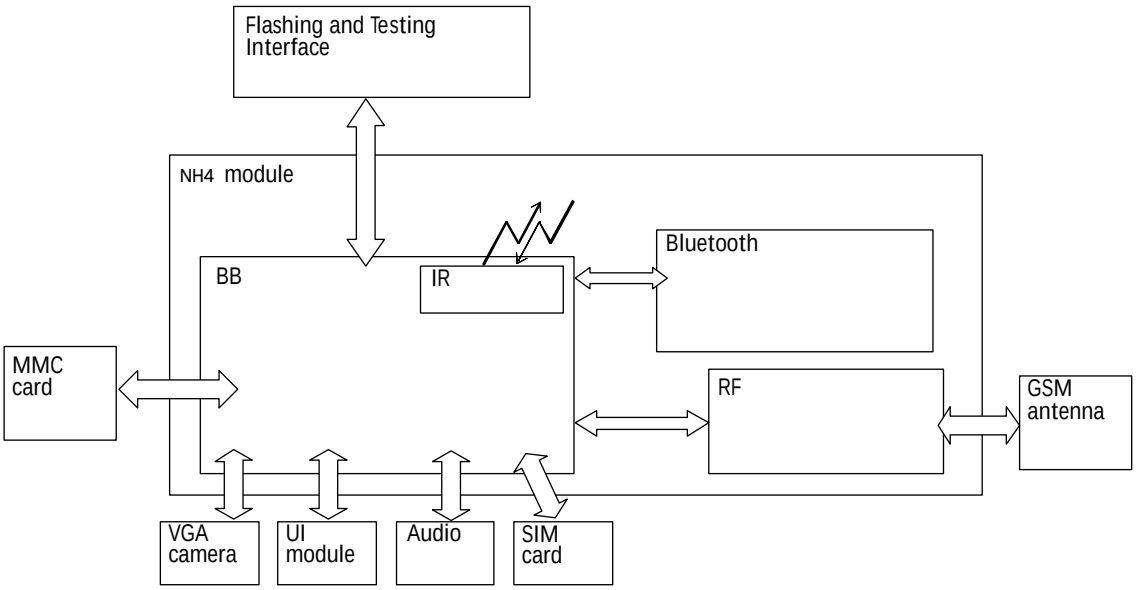
Introduction

The system module NHL-10 consists of the Radio Frequency (RF) and Baseband (BB), including the User Interface (UI) with Keyboard.

System Module Block Diagram

The NH4 System module is the engine board of the NHL-10 phone. It includes the baseband and RF functions of the phone, as well as Bluetooth and camera modules. (See Figure 1.) External interfaces are drawn as arrows crossing the NH4 border.

Figure 1: Module Block Diagram



The Accessory interface is provided by Bluetooth and 115.2kbit IR. Only the Headset & Charger are galvanic interfaces.

Functional description

The heart of the BB is UPP_WD2, which includes the MCU, DSP and Digital Control Logic. Power is supplied by the UEMK ASIC and a number of discrete regulators. Memory comprises of 4 x 64Mbit Flash Memory Devices and 128 Mbit (16 Mbytes) SDRAM.

There are two audio transducers (Earpiece 8 mm and IHF Speaker 16 mm) and an External Galvanic Headset (DCT4) interface. The IHF Speaker is also used to handle the ring tone. The IHF Speaker is driven by a discrete audio amplifier. In NHL-10 there is only one microphone for both HS and IHF modes.

For Data connectivity there is a 115.2kbit IR Module (IrDA compatible), Bluetooth and MMC card.

The Display is an TFT type Colour Display with 65536 Colours and 176x208 pixels with backlighting. The UI module features a keymat and a navigation key.

For imaging purposes, the BB supports a VGA camera via the CCP interface, which is integrated into UPP_WD2.

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BB Description

The BB Core is based on UPP_WD2 CPU, which is a PDA version of the DCT4 UPP ASIC. UPP_WD2 takes care of all the signal processing and operation controlling tasks of the phone, as well as all PDA tasks.

For power management, there is one main ASIC for controlling charging and supplying power UEMK plus some discrete power supplies. The main reset for the system is generated by the UEMK.

The interface to the RF and audio sections is also handled by the UEMK. This ASIC provides A/D and D/A conversion of the in-phase and quadrature receive and transmit signal paths and also A/D and D/A conversions of received and transmitted audio signals. Data transmission between UEMK and RF and the UPP_WD2 is implemented using different serial connections (CBUS, DBUS and RFBUS). Digital speech processing is handled by UPP_WD2 ASIC.

A real time clock function is integrated into the UEMK, which utilizes the same 32kHz-clock source as the sleep clock. A rechargeable battery provides backup power to run the RTC when the main battery is removed. Backup time is 20 hours.

Memory Configuration

NHL-10 uses two kinds of memories, Flash and SDRAM. These memories have their own dedicated bus interfaces to UPP_WD2.

Synchronous DRAM is used as the working memory. The interface is 16 bit wide data and 14 bit Address. The memory clocking speed is 104 MHz. The SDRAM size 128Mbits.

SDRAM I/O is 1.8 V and core 1.8 V supplied by the UEMK regulator VIO. All memory contents are lost if the supply voltage is switched off.

The Multiplexed Flash Memory Interface is used to store the MCU program code and User Data. The memory interface is a burst type FLASH with multiplexed address/data bus, running at 104/3MHz.

Both Flash I/O and core voltage are 1.8 V supplied by the UEMK's VIO.

Energy Management

The master of EM control is UEMK, and with the SW this has the main control of the system voltages and operating modes.

Modes of Operation

NHL-10 employs several hardware and SW controlled operation modes. Main modes are described below.

- The NO_SUPPLY mode means that the main battery is not present or its voltage is too low (below the UEMK master reset threshold) and the back-up battery voltage is too low.
- In the BACK_UP mode the main battery is not present or its voltage is too low but the back-up battery has sufficient charge in it.
- In the PWR_OFF mode the main battery is present and its voltage is over the UEMK master reset threshold. All regulators are disabled.

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- The RESET mode is a synonym for the start-up sequence and contains in fact several modes. In this mode regulators and oscillators are enabled and after they have stabilized, the system reset is released and the PWR_ON mode entered.
- In the PWR_ON mode the SW is running and controlling the system.
- The SLEEP mode is entered from the PWR_ON mode when the system's activity is low (SLEEPX controlled by SW).
- FLASHING mode is for production SW download.

Voltage limits

In the following table the voltage limits of the system are listed. These are also controlling system states.

Table 1: Voltage limits

Parameter	Description	Value
V_{MSTR+}	Master reset threshold (rising)	2.1 V (typ.)
V_{MSTR-}	Master reset threshold (falling)	1.9 V (typ.)
V_{COFF+}	Hardware cutoff (rising)	3.1 V (typ.)
V_{COFF-}	Hardware cutoff (falling)	2.8 V (typ.)
V_BU_{COFF+}	Back-up battery cutoff (rising)	2.1 V (typ.)
V_BU_{COFF-}	Back-up battery cutoff (falling)	2.0 V (typ.)
SW_{COFF}	SW cutoff limit (> regulator drop-out limit) MIN!	3.3 V SW changeable

The master reset threshold controls the internal reset of the UEMK. If the battery voltage is above V_{MSTR}, the UEMK's charging control logic is alive. Also, the RTC is active and supplied from the main battery. Above V_{MSTR}, the UEMK allows the system to be powered on although this may not succeed due to voltage drops during start-up. The SW can also consider battery voltage too low for operation and power down the system.

Clocking Scheme

A 26 MHz VCXO is used as system clock generator in GSM. During the system start-up, UEMK RC-oscillators generate timing for state machines. All clock signals of the engine are illustrated in the following figure.

Bluetooth uses a 26 MHz clock.

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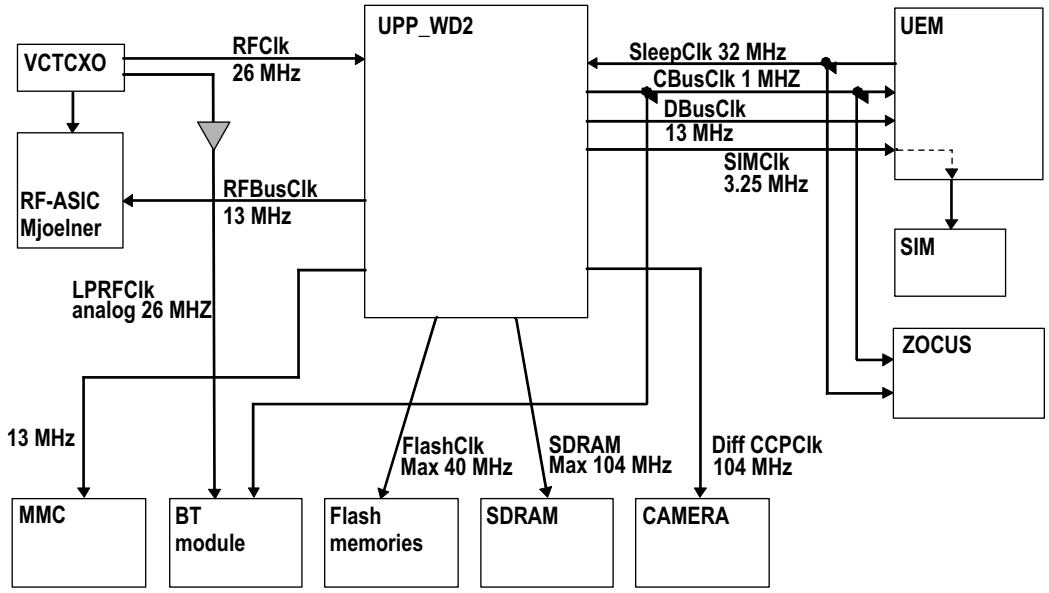
Figure 2: NHL-10 Clocking



In the SLEEP mode the VCXO is off. The UEMK generates a low frequency clock signal (32.768 kHz) that is fed to UPP_WD2, Bluetooth and ZOCUS.

UPP_WD2 voltage/clock frequency adjusting

No external clock is available for UPP_WD2 before VCXO starts. As the reset is released, the VCXO is running and the MCU uses the 26 MHz clock while the DSP is in reset. There are three identical DPLL's, for the MCU, for the DSP and for accessory interfaces, which can be controlled independently. The clock for the MCU can be up to 104 MHz and 117 MHz is maximum clock Frequency for the DSP. These clock signals are used either directly (SDRAM IF) or divided down for the interfaces (e.g. flash IF).

Power Distribution, Control and Reset

All power (except backup battery power) is drawn from BL-5C Li-Ion battery located in the B cover. Current flows through the ZOCUS current sense resister which is used for current measurement by ZOCUS and thus for remaining operating time estimation.

The NH4 board contains one power ASIC, UEMK and discrete regulators needed for generating the different operating voltages. The discrete regulators consist of an SMPS to power UPPWD2 voltage core. In addition there is an SMPS in NH4 generating the operating voltage for display module backlighting. In NH4 the keyboard backlight is powered with a charge pump.

Power-up sequence (Reset mode)

The RESET mode can be entered in four ways: by inserting the battery or charger, by RTC alarm or by pressing the power key. The VCXO is powered by the UEMK. After a 220 ms delay regulators are configured and the UEMK enters the PWR_ON mode and the system reset PURX is released.

During system start-up, in the RESET state, the regulators are enabled, and each regulator charges the capacitor(s) at the output with the maximum current (short circuit current) it can

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deliver. This results in battery voltage dropping during start-up. When a battery with voltage level just above the hardware cutoff limit is inserted, the system may not start due to excessive voltage dipping. Dropping below 2.8 V for longer than 5 us forces the system to the PWR_OFF state.

Powering off

Controlled powering off is done when the user requests it by pressing the power-key or when the battery voltage falls too low. Uncontrolled powering off happens when the battery is suddenly removed or if over-temperature condition is detected in regulator block while in RESET mode. Then all UEMK's regulators are disabled immediately and discrete regulators are disabled as Vbat supply disappears.

Controlled powering off

For NHL-10, powering off is initiated by pressing the power key and Power off sequence is activated in UEMK and SW. Basically, the Power key causes UEMK Interrupt to UPP_WD2 and the SW sets the Watchdog time value to zero and as this happens, PURX is forced low and all regulators are disabled.

If the battery voltage falls below the very last SW cutoff level, the SW will power off the system by letting the UEMK's watchdog elapse.

If thermal shutdown limit in the UEMK regulator block is exceeded, the system is powered off. System reset PURX is forced low.

Uncontrolled powering off

This happens when the battery is suddenly removed. UEMK's state machine notices battery removal after the battery voltage has been below V_{COFF-} for 5 us and enters the PWR_OFF mode. PURX is set low and all UEMK's regulators are disabled.

Watchdogs

There are three watchdogs in the UEMK. The first one is for controlling system power-on and power-down sequences. The initial time for this watchdog after reset is 32 s and the watchdog can not be disabled. The time can be set using a register. This watchdog is used for powering the system off in a controlled manner. The other one is for the security block and is used during IMEI code setting. The third one is a power key watchdog. It is used to power off the system in case the SW is stuck and the user presses the power key. This WD is SW configurable.

There is also a "soft watchdog" in UPP_WD2. It is used to reset the chip in case the software gets stuck for any reason. The Bluetooth module also contains a watchdog.

Charging

Charging control and the charge switch is in the UEMK. There are two different charging modes; charging an empty battery (start-up charge mode), and SW controlled charging.

The UEMK digital part takes care of charger detection (generates interrupt to UPP_WD2), pulse width modulated charging control (for internal charge switch) and over voltage and current detection. The SW using registers controls all these.

Chargers

NHL-10 BB supports a standard charger (two wires); ACP-12 and Cigarette Charger LCH-12 officially.

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Battery

The NHL-10 battery is a detachable, semi-fixed Lithium-Ion BL-5C battery. The nominal voltage is thus 3.7 V (max charging voltage 4.2 V).

The interface consists of three pins: VBAT, GND and BSI. The pull-down resistor inside the batteries (BSI signal) recognizes the battery types. Voltage level at the BSI line is measured using the UEMK's AD-converter.

Back-up battery and real time clock

The real time clock (RTC), crystal oscillator and back-up battery circuitry reside in the UEMK. A register in the UEMK controls back-up battery charging and charging is possible only in POWER_ON State.

Baseband Measurement A/D Converter

The UEMK contains 11 channels A/D converter, which is used for different Baseband measurement purposes. The resolution of the A/D converter is 10 bits. The converter uses the CBUS interface clock signal for the conversion. An interrupt will be given to the MCU at the end of the measurements. The Converter is used for following purposes.

- Battery Voltage Measurement A/D Channel (Internal)
- Charger Voltage Measurement A/D Channel (Internal)
- Charger Current Measurement A/D Channel (External)
- Battery Temperature Measurement A/D Channel (External)
- Battery Size Measurement A/D Channel (External)
- LED Temperature measurement A/D Channel (External)

There is also an auxiliary AD converter in the UEMK, which is used to monitor RF functions.

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ZOCUS

The ZOCUS device is a current sensor used for the battery bar display and for determining whether the phone is in a high current consuming mode. The ZOCUS device measures the voltage drop across a sense resistor in the battery voltage line. This sense resistor is formed from a PWB track and is on an internal layer of the PWB. The sense resistor must be located close to the battery terminals so that all of the phones current flow through it. The nominal value of the sense resistor is 3.0m-ohm. ZOCUS reports the current measurement to UPP_WD2 via the Cbus interface.

NHL-10 BB Features and HW Interfaces

NHL-10 BB User interface

UI-Module Interface

The UI-Module consists of the LCD and keymat. The Colour Display resolution is 176 x 208 and backlighting is via 4 white LED's with a lightguide. The display is connected to the NH4 module via a 24-pin plug and socket. The keymat is connected to NH4 by a 20-pin contact type connector. Interface also includes power rails for keypad backlight. The keymat interface uses the GPIO pins of UPP_WD2.

Bluetooth

Bluetooth provides a fully digital link for communication between a master unit and one or more slave units. The system provides a radio link that offers a high degree of flexibility to support various applications and product scenarios. Data and control interface for a low power RF module is provided. Data rate is regulated between the master and the slave.

IR

The NHL-10 BB uses TDFU5102 1Mbit IrDA 1.1 compatible module. Module interface signals are Tx (Transmitted Data), Rx (Received Data) and SD (ShutDown). IR transmission data speed can be from 9.6 kbit/s to 115.2kbit/s. The communication over the IR is always started using bit rate 9.6 kbit/s.

Digital part is powered with 2.78 V by VFLASH1 and the LED by VBAT.

SIM Interface

The SIM interface is located in two chips (UPP_WD2 and UEMK). In the UEMK, there is only support for one SIM card. The interfaces support both 1.8 V and 3 V SIM cards. An adjustable SIM regulator (1.8V/3.0V) is located in the UEMK and can be controlled by the SW.

The data communication between the card and the phone is asynchronous half duplex. The clock supplied to the card is 3.25 MHz. The data baudrate is SIM card clock frequency divided by 372 (by default), 64, 32 or 16.

MMC Interface

The MMC interface consists of a block in UPP_WD2 plus a level shifting device known as "Lester" and an EMC protection ASIP. The MMC interface comprises 3 lines, clock, data and com-

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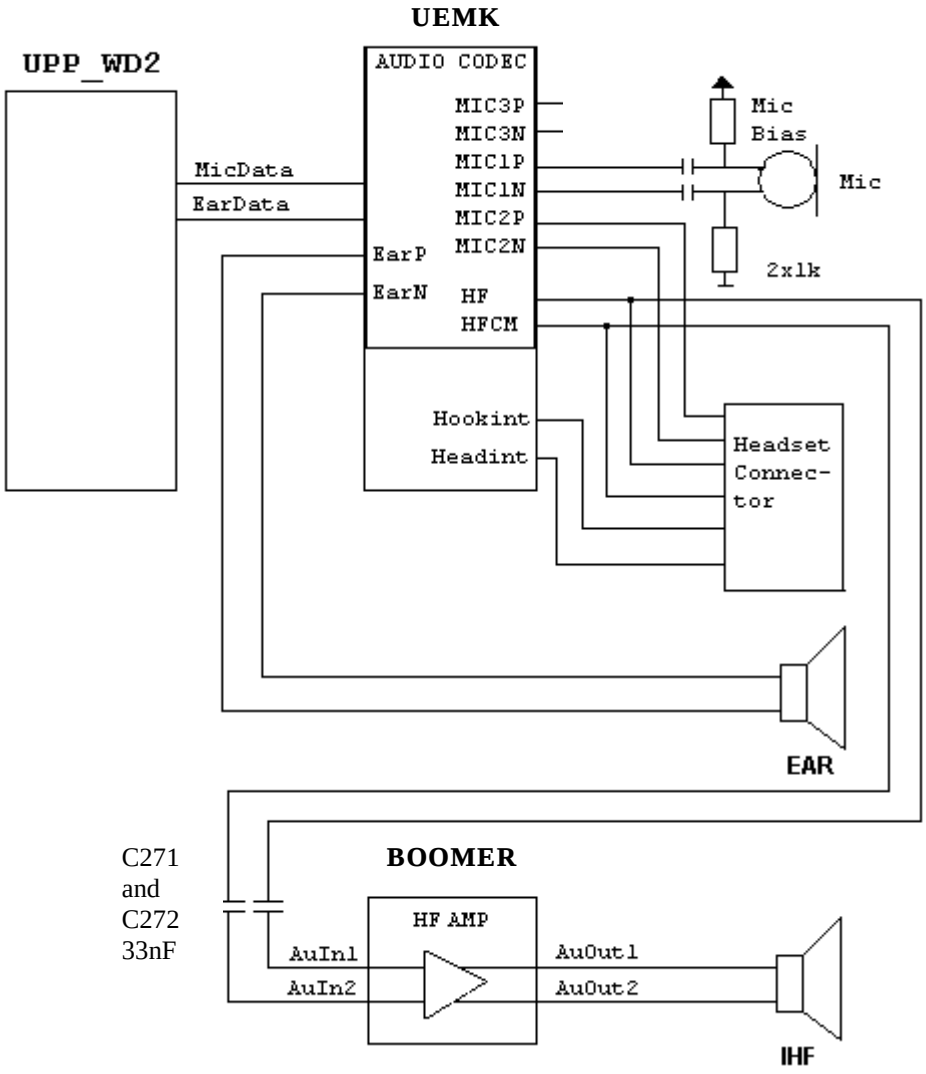
mand, and runs at 8.66 MHz. The Lester device also incorporates a 2.85V regulator to power the MMC card.

NHL-10 Audio Concept

The NHL-10 Audio includes earpiece, microphone, and headset connector and Integrated Handsfree (IHF). Audio is based on ASIC's UPP_WD2, UEMK and a discrete amplifier for the handsfree speaker known as the boomer.

Figure 3: Audio Blocks



Between UPP_WD2 and the UEMK the audio signals are transferred in digital format using signals MICDATA and EARDATA. The headset output of the UEMK is also fed to boomer, i.e. the handsfree speaker and the headset share the same output lines from the UEMK. Ringing tones and warning/info tones are to be produced with the IHF speaker, too.

Earpiece

The earpiece to be used in NHL-10 is an 8-mm Pico earpiece produced by Philips Speaker Systems. It has 32Ω continuous impedance and continuous power 8 mWatts. It's driven by dif-

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ferential signals from the UEMK (EARP & EARN). It makes contact with the PWB via spring contacts.

Microphone

The microphone capsule for NHL-10 is a WM_EZZ CY327 capsule. Its sensitivity is -42db Nominal. Contacts are done by springs.

Two inputs are used from the UEMK, one for normal internal microphone and a second for the headset. The third microphone input is not used, so it is connected to the ground via capacitors. Microphone bias block in the UEMK generates bias voltages for handportable and handsfree/ headset microphones. For both microphone bias outputs (MICB1 & MICB2), the minimum output voltage is 2.0 Volts and maximum output current is 600 µA. The microphone bias block also includes a low pass filter for the reference voltage used as an input for the MICB1&2 amplifiers.

IHF Amplifier and Speaker

The speaker to be used in NHL-10 is a 16mm 8Ω speaker. It can handle 0.2 Watts nominal power and a peak power of 0.3 Watts. The component is housed in the antenna housing and connects to the PWB via spring contacts.

HF and HFCM lines of the UEMK are used to drive the boomer IHF amplifier.

The power amplifier is a differential opamp. The differential output drives the HandsFree speaker. The HandsFree amplifier load impedance is 8 ohm.

The outputs go into a high impedance state when powered down. The amplifier can be enabled and shut down using a GENIO line from UPP_WD2.

SW controls IHF and earpiece volume via UEMK. Gain setting can be done in 2 dB steps, from –40 to +6 dB. The output sound pressure level of the internal HandsFree speaker is controlled by SW (CBus is used for controlling).

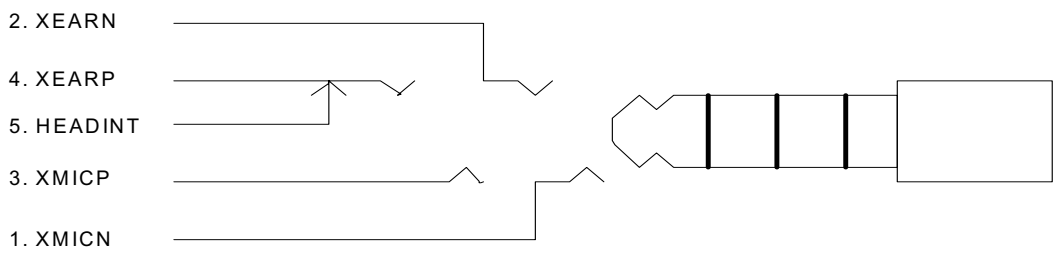
The schematic around the Boomer IHF amplifier is presented in NHL-10 schematics. The schematic shows all the filtering needed and also protection components against ESD and EMC.EMC and ESD Filtering component must be as near as possible to earphone pads of the phone.

The supply voltage for the IHF amplifier is taken directly from the battery voltage.

External Audio interface

In NHL-10 there is a Headset Connector which is a fully differential 4–wire connection.

Figure 4: External Audio Connector



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The Handsfree (HF) driver in the UEMK is meant for the headset. In the NHL-10 case the output is driven in a fully differential mode. In the fully differential mode, the HF pin is the negative output and HFCM pin is the positive output. The gain of the Handsfree driver in the differential mode is 6 dB. The earpiece (EARP, EARN) and headset (HF, HFCM) signals are multiplexed so that the outputs cannot be used simultaneously. The HF and HFCM amplifiers include a transient suppression circuitry, which prevents unwanted spikes in HF and HFCM outputs when switching on and off the amplifiers.

The plug will open a mechanical switch inside the connector between HF and HeadInt lines. The HeadInt line will be pulled up to 2.7V by internal resistor when the switch is open. When not having the plug inserted the voltage in the HeadInt line will be <0.8 V caused by an internal pull down resistor in the HF line.

Camera Interface

The NHL-10 camera is a still camera with viewfinder option. The camera resolution is VGA. The Camera module is connected by means of a soldered on connector to the PWB.

The camera interface is a serial CCP, which is a unidirectional interface; the control information to camera is transmitted through I2C bus. The I2C is implemented purely by the SW using general purpose I/Os.

The CCP interface consists of differential clock data signal. The CCP enables the use of high data rates with low EMI; maximum transfer capacity is 104 Mbit/s, which means that transferring VGA (640 x 480) images at 15 fps is possible.

Flashing

SW download in service is implemented by custom tools and SW. For further information, please refer to Service Software Instructions and Service Tool sections of the manual.

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Testing interfaces

Table 2: Testing Interface Electrical Specifications

Pin	Name	Dir	Parameter	Min	Typ	Max	Unit	Notes
1	MBUS	<->	Vol	0	0.2	0.3*VFlash1	V	
			Vil (From Prommer)	0	0.2	0.3*VFlash1	V	
			Voh	0.7*VFlash1	2.7	0.7*VFlash1	V	
			Vih(From Prommer)	0.7*VFlash1	2.7	VFlash1	V	
2	FBusTx	->	Vol	0	2.7	0.3*VFlash1	V	
			Voh	0.7*VFlash1	2.7	VFlash1	V	
3	FBusRx	<-	Vil (From Prommer)	0	2.7	0.3*VFlash1	V	
			Vih(FromPrommer)	1.89	2.7	VFlash1	V	
			Abs. Max. Voltage to Test Pad Referenced to GND	-0.3V		3.0	V	Absolute Max Voltage limits to MBUS/ FBUS
4	VPP		To Phone	0 / 2.8 / 12 +/-3%			V	Prommer Select
5	GND				0		V	VBAT GROUND

Note: VFlash1 is 2.78 +/- 3%

Table 3: Electrical Specifications for Power Supply Interface in Product Testing

Pin	Name	Min	Typ	Max	Unit	Notes
1	VBAT	0	3.6	5.1	V	
2	BSI	0	2.78	VFlash 1	V	Internal pullup
3	BTEMP	0	3.0	VAna	V	Internal pullup
4	GND	0			V	

Note: VAna and VFlash1 = 2.78 +/-3%

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Extreme Voltages

Lithium-Ion battery BL-5C (1 cell):

- Nominal voltage is 3.7V.
- Lower extreme voltage is 2.8V (cut off voltage).
- Higher extreme voltage is 4.2V (charging high limit voltage).

Temperature Conditions

Specifications are met within the range of –10^{o}C to +55^{o}C ambient temperature. Reduced operation between [-30] and [+60]. Storage temperature range is of –40^{o}C to +85^{o}C.

Humidity and Water Resistance

The relative humidity range is 5 to 95%. Condensed or dripping water may cause intermittent malfunctions. Protection against dripping water has to be implemented in (enclosure) mechanics. Continuous dampness will cause permanent damage to the module.

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